Appendix E

I/I Pilot Project Rainfall Monitoring

Description:

This appendix documents the rainfall monitoring and data development conducted for the subsequent modeling and analysis.

Reference Chapter:

Chapter 8 – Rehabilitation Effectiveness

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RAINFALL MONITORING

BACKGROUND

Rainfall time series were developed for the pilot project modeling basins as a composite of CALAMAR events and rain gauge data. Time series of rain gauge readings were first developed by combining the three nearest correctly working rainfall gauges that triangulated the modeling area into one data set. Note that four gauges were used if the three nearest were missing a large amount of data. The gauges were combined using a simple inverse distance weighted interpolation approach, with a weighting power of two, and the distance represented by the distance from the gauge to the centroid of the modeling basin. After the rain gauge time series were developed, the CALAMAR event time series were substituted into the rain gauge time series to become a composite time series.

RAINFALL TIME SERIES

The King County Wastewater Treatment Division (WTD) and Water and Land Resources Division (WLRD) each operate a network of rain gauges throughout King County. For each pilot project modeling basin, nearby WLRD and WTD rain gauges were combined into one representative rainfall time series. The three closest gauges that triangulated the modeling area of concern were combined at a 5-minute time interval. When the three closest gauges were missing a large amount of data, the next closest gauge was also added to the combination. Gauges that were not working properly during any given period were excluded from the analysis. See Table 1 for a list of the gauges used to develop the rainfall time series for each modeling basin.

Table 1
Rain Gauges Used to Develop Rainfall Time Series

Agency	Pilot/Mini Basin	Sub-Basin	Rain Gauge	Rain Gauge	Rain Gauge	Rain Gauge
Auburn	ABN002	Pilot Control	LOWG LOWG	COVG COVG	LHPS LHPS	
Kent	KNT014	Pilot Control	MOIN MOIN	KENT KENT	STAR STAR	SEQU SEQU
ValVue	VAL019	Pilot	REBA	TUKW	MOIN	
ValVue	VAL017	Control	REBA	TUKW	MOIN	
Skyway	BLS002	Pilot Control	HAMM HAMM	MAPL MAPL	TUKW TUKW	
Coal Creek	CCR002	Pilot	MERC	FACT	HEAT	LOWM
Coal Creek	CCR009	Control	MERC	FACT	HEAT	LOWM
Mercer Island	MRC012	Pilot Control	PINE PINE	MEDI MEDI	MERC MERC	RAIN RAIN
Kirkland	KRK011	Pilot Control	JBAY JBAY	KIRK KIRK	YARR YARR	
Northshore	NUD038	Pilot	KENM	NORW	NCKR	BOTH
Northshore	BOT012	Control	KENM	NORW	NCKR	BOTH

Agency	Pilot/Mini Basin	Sub-Basin	Rain Gauge	Rain Gauge	Rain Gauge	Rain Gauge
Brier	BRR004	Pilot Control	LYON LYON	KENM KENM	BOTH BOTH	
Lake Forest Park	RON041	Pilot	LYON	KENM	City of Seattle RG1	
Lake Forest Park	RON039	Control	LYON	KENM	City of Seattle RG1	
Ronald	RON002	Pilot	BOEN	LYON	City of Seattle RG1	
Ronald	RON045	Control	BOEN	LYON	City of Seattle RG1	
Redmond	RDM009	Pilot Control	HOLL HOLL	NOVH NOVH	KIRK KIRK	XRDS XRDS

The gauges were combined with a simple inverse distance weighted interpolation method. The centroid of the basin was chosen as the point of reference for the distance estimate to the surrounding gauges. The weighting power was set to the square. Other weighting powers were considered; however, the square qualitatively best represented the data and is assumed to be an optimal standard among the scientific community.

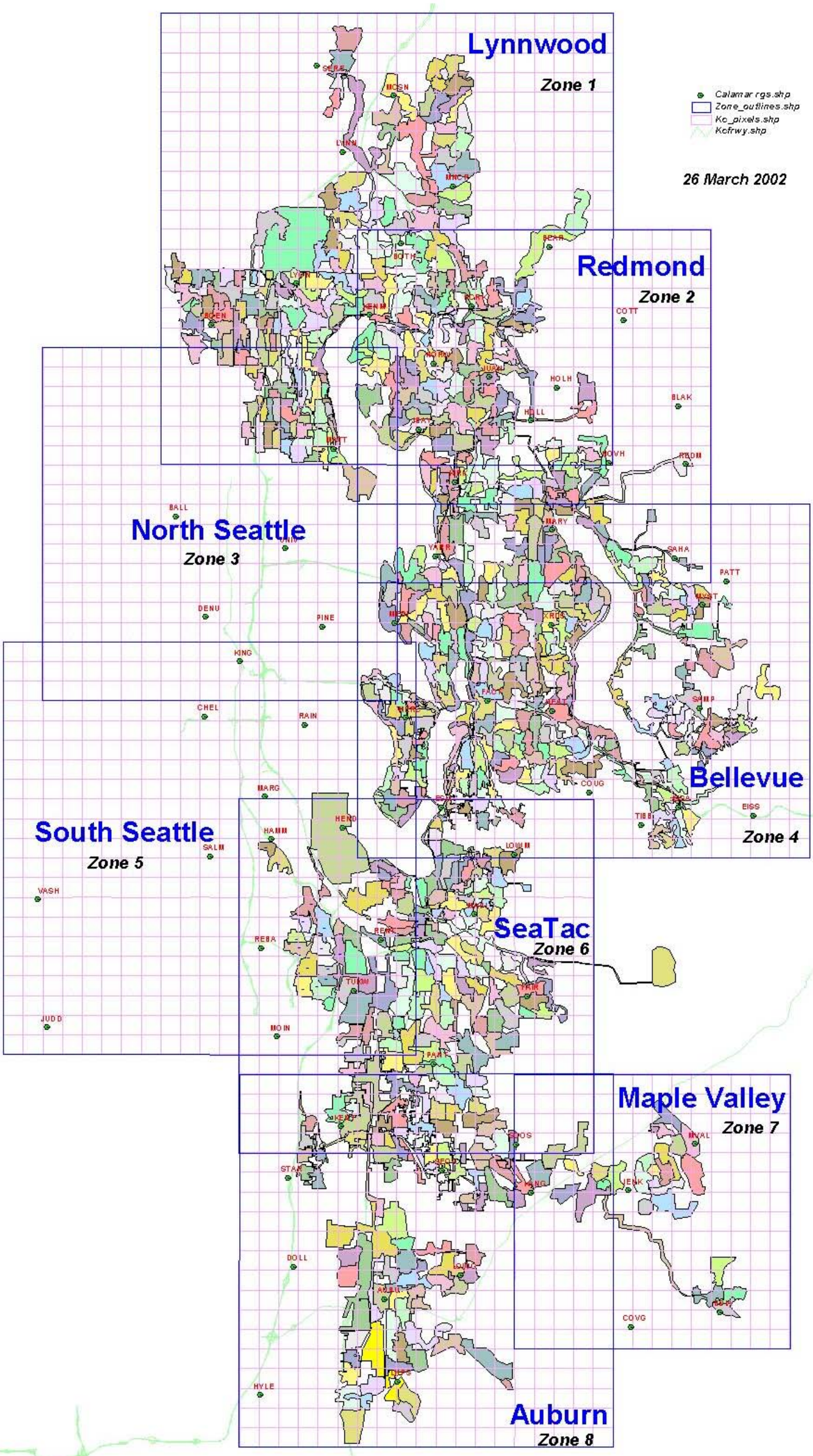
CALAMAR EVENT TIME SERIES

Principles of Radar Technology and CALAMAR

CALAMAR (CAlcul de LAMes d'eau a l'Aide du Radar--translates to "Calculating Rain with the Aid of Radar") was used to calculate rainfall during storm events. CALAMAR operates by acquiring raw reflectivity images from the NEXRAD radar and processing the data with a geographic resolution of 1 km^2 pixels and a 5-minute temporal resolution. Rain gauges provide "ground truth" such that, when calibrated, a pixel containing a rain gauge will show approximately the same rainfall value as a rain gauge within that pixel. This works well on a storm-by-storm basis since each type of storm cell produces a characteristically similar radar image. However, using the technology over a large service area provides the opportunity for multiple storms of different characteristics to occur simultaneously within the service area. In order to assure that only the rainfall in each region is used to calibrate the radar image for that region, the King County service area was separated into eight calibration zones of 200 to 500 km^2 each (see Figure 1).

The CALAMAR calibration process was adjusted in 2004 in the Lynnwood and Redmond zones to take into account the frequent occurrence of the bright band filling the radar beam south of the Lynnwood zone and in most of the Redmond zone. The bright band affects the translation of the raw NEXRAD reflectivity image to rainfall. The rain gauges used to calibrate these zones were adjusted; however, the zone definitions were not affected.

Figure 1
CALAMAR Calibration Zones



Network of Calibrating Rain Gauges

The King County WTD and WLRD network of rain gauges was used for calibration by CALAMAR. An additional 25 gauges were installed to create sufficient density for calibration. Rain gauge BOTH was relocated approximately 1/4 mile east during the summer of 2001. Table 2 is an inventory of all King County rain gauges.

Table 2
Rain Gauge Inventory

WLRD GAUGE_#	GAUGE_NAME	CALAMAR NAME	DESCRIPTION
02V	Blakely Ridge	BLAK	Blakely Ridge Precipitation, near Redmond.
04U	Boeing Creek	BOEN	Shoreline Community College near Seattle.
02W	Cottage Lake	COTT	At King County Fire Station near Cottage Lake
63Y	Cougar Mountain	COUG	Cougar Mountain Park
09U	Covington Creek	COVG	Near Horseshoe Lake, near Black Diamond.
11U	Des Moines Creek	MOIN	In Tyee Golf Course, in SeaTac.
14U	East Fork Issaquah	EISS	East Fork Issaquah Precipitation, west of High Point.
31Y	Fairwood	FAIR	None
HCU	Hamm Creek	HAMM	None
51W	Hollywood Hill	HOLH	In Hollywood, north of Redmond.
26U	Jenkins Creek	JENK	Near Shadow Lake.
27U	Juanita Creek	JUAN	K.C. Fire Station in Kingsgate.
28U	Judd Creek	JUDD	Vashon Cemetery
41V	Lake Dolloff	DOLL	South of Lake Dollof, near Federal Way.
42U	Lake Reba	REBA	Near Lake Reba detention facility.
32U	Lower Green River	LOWG	At K.C. Fire Station, near Auburn.
37U	Lower May Creek	LOWM	Near Renton.
35U	Lyons Creek	LYON	At Brugers Bog KCPW Shop in Lake Forest Park.
31U	Maplewood	MAPL	Near Renton.
MLU	Mystic Lake	MYST	At Fire station
24V	East Fork Hylebos	HYLE	East Fork Hylebos
43U	North Vashon	VASH	Heights Water District
51U	Norway	NORW	South Bothell.
03Y	Panther Creek	PANT	Panther Regional Detention Pond, near Kent.
48U	Patterson Creek	PATT	SR 202 near Redmond.
18V	Redmond UPD	REDM	In Northridge UPD
50U	Salmon Creek	SALM	15th Ave SW north of SW 106th ST.
54V	Soos Creek	SOOS	In Soos Creek Park.
41U	Star Lake	STAR	South of Star Lake, near Federal Way.
67U	Tibbetts Creek	TIBB	On SR 900, near Issaquah.
WTD GAUGE_#	**GAUGE_NAME**	**CALAMAR NAME**	**DESCRIPTION**
XXXXXX0770	25 West Main St., Auburn	AUBU	City Hall, 25 West Main St., Auburn
XXXXXX4992	5000-6000 block James, Kent	KENT	5000-6000 block James, Kent
XXXXXX3145	525 1st Ave., Issaquah	ISSA	525 1st Ave., Issaquah
LQF815078VL	Ballard RS	BALL	Ballard RS
LQF806078VL	Chelan RS	CHEL	Chelan RS
LQF602078VL	RG at Dexter and Republican	DENN	RG at Dexter and Republican
LQF813178VL	Denny Way RS	DENU	Denny Way RS
LQF773078VL	East Marginal Way PS	MARG	East Marginal Way PS
LQF783078VL	East Pine PS	PINE	East Pine PS
LQF335214VL	ESI Sect. 4, MH R02-25, Renton	ESI4	ESI Sect. 4, Manhole R02-25, Renton
	Heathfield PS	HEAT	Heathfield PS
LQF774078VL	Henderson PS	HEND	Henderson PS
LQF308078VL	Hollywood PS	HOLL	Hollywood PS
LQF788078VL	Kenmore PS	KENM	Kenmore PS
LQF801078VL	King Street RS	KING	King Street RS
LQF786078VL	Matthews Park PS	MATT	Matthews Park PS

LQF770078VL	Rainier Ave PS	RAIN	Rainier Ave PS
LQF819078VL	University RS	UNIV	University RS
New WTD Gauges	**New RG_NUMBER**	**CALAMAR NAME**	**DESCRIPTION**
N/A	1	SEQU	Sequoia Jr. HS
N/A	2	LHPS	Lakeland Hills PS
N/A	3	KANG	Fire Station, 15635 Kent Kangley
N/A	4	MVAL	Maple Valley Retention Pond D92151
N/A	5	BDIA	Black Diamond PS, Jones Lake rd.
N/A	6	MERC	School Admin. Mercer Island
N/A	7	FACT	Factoria Transfer Station
N/A	8	MEDI	Medina PS
N/A	10	XRDS	Fire Station 3, 16100 NE 8th St
N/A	11	SAMP	Retention Pond, 235th Pl. N & 32nd St
N/A	12	SAHA	Retention Pond, 22124 Redmond Fall City Rd
N/A	13	NOVH	Retention Pond, 18808 103rd St. D90930
N/A	14	MARY	Marymoor Park
N/A	15	KIRK	Kirkland Maint. Center, 915 8th St
N/A	16	YARR	Yarrow Bay PS
N/A	17	NCRK	North Creek PS
N/A	18	BEAR	Retention Pond, 229th St SE & 75 Av SE
N/A	19	MNCR	Retention Pond, 19812 26th Dr. SE
N/A	20	BOTH	Intermountain Glass, 23905 Meridian Av. S
N/A	21	LYNN	Lynnwood HS
N/A	22	MCSN	Alderwood PS 17, Mill Creek
N/A	23	SERE	Fire Station 3, 4323 Serene Way
N/A	24	TUKW	Tukwila PS
N/A	25	RENT	Renton WWTP
N/A	26	JBAY	KC Service Center, Juanita Dr and 93rd Av.
Note: New WTD Gauge Number 9 not placed for the study			

In addition to the rain gauges listed above, 2 Snohomish County gauges and 17 City of Seattle gauges were also used for calibration by CALAMAR. Thus, the total number of calibration gauges was 92.

CALAMAR Events

The CALAMAR event time series were developed for all rainfall events corresponding to the flow monitoring periods. Seven rainfall events were selected during both the pre- and post-rehabilitation monitoring periods as events that created a measurable I/I response in the project basins. Rainfall events that were affected by snowfall were not included. Table 3 lists the selected events.

Table 3
CALAMAR Events

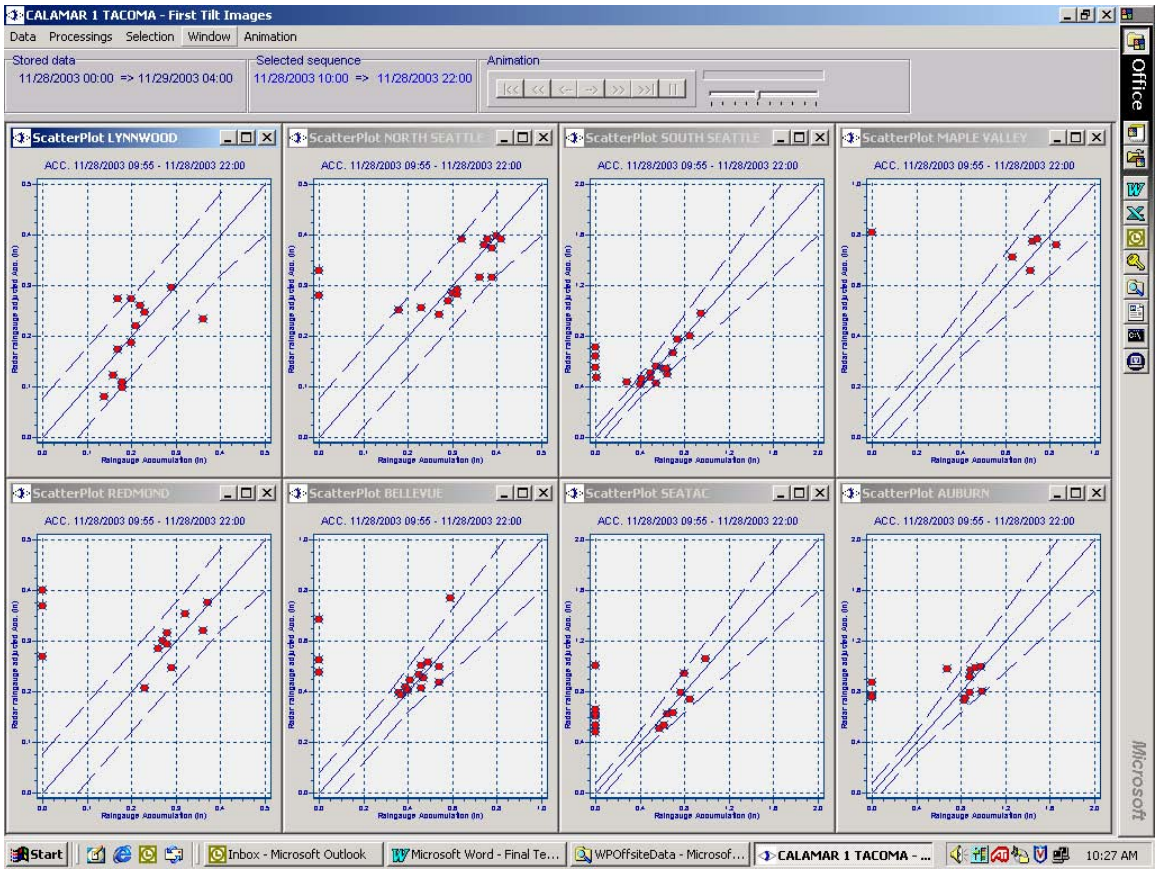
Storm	Event Start Time	Event Stop Time
2002/03 Pre-Rehab Monitoring Season		
1	12/13/2002 12:20 12/14/2002 2:15	12/13/2002 21:45 12/15/2002 3:10
2	12/15/2002 4:00 12/15/2002 21:00 12/17/2002 0:00	12/15/2002 6:00 12/16/2002 9:35 12/17/2002 10:25
3	1/1/2003 8:30 1/1/2003 23:30 1/2/2003 3:00 1/2/2003 6:00 1/2/2003 16:30	1/1/2003 22:30 1/2/2003 3:00 1/2/2003 6:00 1/2/2003 12:15 1/3/2002 0:00
4	1/4/2003 4:30	1/4/2003 12:30
5	1/21/2003 0:00 1/21/2003 9:30 1/22/2003 6:00 1/23/2003 2:20	1/21/2003 5:00 1/21/2003 13:30 1/22/2003 16:55 1/23/2003 4:30
6	3/12/2003 1:15 3/12/2003 9:15	3/12/2003 6:20 3/13/2003 3:15
7	3/21/2003 0:00 3/21/2003 13:00 3/21/2003 21:00 3/22/2003 3:00 3/23/2003 8:30	3/21/2003 7:00 3/21/2003 21:00 3/22/2003 3:00 3/22/2003 9:00 3/24/2003 0:00
2003/04 Post Rehab Monitoring Season		
1	10/19/2003 22:30	10/21/2003 5:00
2	11/17/2003 18:00	11/19/2003 3:30
3	11/28/2003 10:00	11/28/2003 22:00
4	12/4/2003 15:30 12/4/2003 19:55 12/5/2003 3:00 12/5/2003 7:00	12/4/2003 18:15 12/5/2003 0:00 12/5/2003 7:00 12/5/2003 12:00
5	1/14/2004 2:10	1/14/2004 23:55
6	1/23/2004 13:30	1/23/2004 22:20
7	1/29/2004 3:00 1/30/2004 0:00	1/29/2004 16:00 1/30/2004 2:30

Events were initially chosen based on the I/I response in the project basins. For CALAMAR purposes, events were further broken down into smaller time periods that had similar radar behavior, and dry weather episodes embedded in the initial event were disregarded.

Calibration Scatterplots

The basic tool for evaluating the calibration of each zone is a scatterplot displaying the rain gauge accumulation versus the radar rainfall accumulation for each rainfall event. These scatterplots allow dysfunctional rain gauges to be identified so that they can be disregarded during the calibration of the zone in which they reside. Figure 2 shows an example of the scatterplots for all of the calibration zones for Post-Rehabilitation Storm 3 that occurred on 11/28/2003.

Figure 2
CALAMAR Scatterplots for 11/28/03



As shown on the scatterplots, the rain gauges that fell along the y-axis were measuring zero and not functioning properly. These gauges were disregarded from the calibration.

CALAMAR can also identify inaccurate rain gauges. Inaccuracies can have several causes including plugged funnels, corroded tipping buckets, or being in the "rain shadow" of trees or buildings. Rain shadows exist when a rain gauge is partially obstructed by structures and trees or if nearby buildings significantly alter wind patterns above the rain gauge.

Table 4 lists, for each calibration zone, the percentage of pixels with an accumulation within 20 percent of the accumulation of the associated rain gauge. Because of the change to the CALAMAR calibration process for the Lynnwood and Redmond zones, the storms from the 2001/02 monitoring process were re-evaluated. The results of the re-evaluation are also included in Table 4.

Table 4
CALAMAR Calibration Summary

2001-2002 Monitoring Season

Storm	Storm Start Time	Storm End Time	King County Calibration Zones								Storm Average	No. of Gauges in Calibration
			Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn		
1	11/4/2001 16:40	11/5/2001 2:00	91%	88%	100%	82%	65%	80%	100%	89%	87%	77
2	11/13/2001 15:05	11/14/2001 19:00	91%	100%	100%	100%	94%	100%	100%	100%	98%	
	11/15/2001 6:00	11/15/2001 15:10	82%	75%	86%	100%	59%	100%	100%	78%	85%	
	11/15/2001 18:00	11/16/2001 7:00	100%	100%	100%	91%	100%	100%	100%	100%	99%	77
3	11/19/2001 1:00	11/19/2001 20:25	100%	100%	100%	83%	100%	100%	80%	78%	93%	
	11/19/2001 23:30	11/20/2001 4:35	100%	100%	93%	92%	65%	80%	100%	100%	91%	
	11/20/2001 14:50	11/20/2001 18:50	100%	100%	100%	100%	82%	100%	100%	100%	98%	
	11/20/2001 19:50	11/20/2001 23:55	100%	100%	93%	100%	76%	90%	100%	89%	94%	77
4	11/21/2001 21:30	11/22/2001 5:30	80%	88%	100%	67%	100%	78%	100%	100%	89%	
	11/22/2001 5:30	11/22/2001 13:00	100%	100%	87%	75%	88%	89%	80%	100%	90%	
	11/22/2001 14:00	11/23/2001 4:30	70%	88%	80%	75%	69%	78%	80%	78%	77%	77
5	11/28/2001 3:45	11/28/2001 15:55	78%	75%	79%	50%	56%	78%	60%	100%	72%	
	11/28/2001 18:30	11/18/2001 21:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	11/28/2001 21:00	11/29/2001 0:05	89%	88%	93%	92%	94%	78%	100%	100%	92%	
	11/29/2001 5:35	11/29/2001 14:25	89%	100%	100%	58%	94%	78%	80%	100%	87%	
	11/30/2001 4:00	11/30/2001 7:00	100%	88%	86%	67%	88%	100%	100%	100%	91%	
	11/30/2001 17:00	11/30/2001 22:00	100%	100%	79%	42%	88%	89%	100%	100%	87%	75
6	12/12/2001 9:30	12/12/2001 14:30	100%	100%	100%	33%	93%	100%	100%	100%	91%	
	12/13/2001 3:30	12/13/2001 21:00	60%	100%	91%	92%	93%	100%	100%	89%	91%	72
7	12/15/2001 9:30	12/15/2001 14:30	100%	88%	87%	33%	69%	100%	80%	67%	78%	
	12/16/2001 0:00	12/16/2001 5:30	100%	100%	93%	75%	93%	60%	100%	78%	87%	
	12/16/2001 5:30	12/17/2001 1:00	80%	88%	93%	67%	69%	90%	100%	56%	80%	77
8	12/31/2001 1:00	12/31/2001 8:00	100%	78%	100%	92%	100%	100%	100%	100%	96%	
	1/1/2002 13:30	1/1/2002 18:00	73%	100%	93%	75%	94%	100%	80%	78%	87%	
	1/1/2002 18:05	1/2/2002 1:00	82%	88%	100%	92%	94%	90%	100%	100%	93%	78
9	1/6/2002 9:25	1/8/2002 1:15	90%	100%	100%	92%	100%	90%	80%	89%	93%	
	1/8/2002 3:30	1/8/2002 5:30	82%	100%	100%	100%	100%	100%	100%	100%	98%	78
10	1/12/2002 1:00	1/12/2002 9:00	91%	100%	60%	92%	80%	100%	100%	100%	90%	78
		Average % within 20%	90%	94%	93%	79%	86%	91%	94%	92%	90%	

2002-2003 Pre-Rehab Monitoring Season

Storm r	Storm Start Time	Storm End Time	King County Calibration Zones								Storm Average	No. of Gauges in Calibration
			Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn		
1	12/13/2002 12:20	12/13/2002 21:45	82%	86%	100%	55%	63%	80%	100%	90%	82%	
	12/14/2002 2:15	12/15/2002 3:10	55%	71%	100%	82%	75%	100%	40%	70%	74%	75
2	12/15/2002 4:00	12/15/2002 6:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	12/15/2002 21:00	12/16/2002 9:35	55%	100%	100%	55%	81%	70%	100%	90%	81%	
	12/17/2002 0:00	12/17/2002 10:25	91%	100%	100%	73%	94%	100%	100%	100%	95%	75
3	1/1/2003 8:30	1/1/2003 22:30	80%	86%	100%	60%	94%	100%	100%	100%	90%	
	1/1/2003 23:30	1/2/2003 3:00	100%	100%	100%	100%	83%	100%	100%	56%	92%	
	1/2/2003 3:00	1/2/2003 6:00	100%	100%	100%	90%	72%	100%	100%	100%	95%	
	1/2/2003 6:00	1/2/2003 12:15	100%	100%	100%	100%	94%	100%	100%	100%	99%	
	1/2/2003 16:30	1/3/2003 0:00	80%	86%	100%	90%	83%	90%	60%	56%	81%	76
4	1/4/2003 4:30	1/4/2003 12:30	80%	100%	100%	90%	94%	100%	100%	78%	93%	76
5	1/21/2003 0:00	1/21/2003 5:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	1/21/2003 9:30	1/21/2003 13:30	100%	100%	100%	100%	100%	89%	100%	78%	96%	
	1/22/2003 6:00	1/22/2003 16:55	82%	100%	100%	91%	76%	100%	100%	89%	92%	
	1/23/2003 2:20	1/23/2003 4:30	91%	100%	93%	100%	53%	78%	100%	100%	89%	76
6	3/12/2003 1:15	3/12/2003 6:20	100%	100%	100%	100%	94%	89%	100%	80%	95%	
	3/12/2003 9:15	3/13/2003 3:15	91%	100%	87%	80%	65%	89%	80%	60%	82%	77
7	3/21/2003 0:00	3/21/2003 7:00	100%	100%	100%	100%	100%	100%	100%	100%	100%	
	3/21/2003 13:00	3/21/2003 21:00	91%	63%	85%	60%	67%	89%	80%	70%	76%	
	3/21/2003 21:00	3/22/2003 3:00	91%	88%	92%	100%	100%	100%	100%	60%	91%	
	3/22/2003 3:00	3/22/2003 9:00	100%	100%	85%	100%	73%	56%	80%	60%	82%	
	3/23/2003 8:30	3/24/2003 0:00	91%	100%	85%	90%	100%	56%	100%	90%	89%	74
		Average % within 20%	89%	95%	97%	87%	85%	90%	93%	83%	90%	

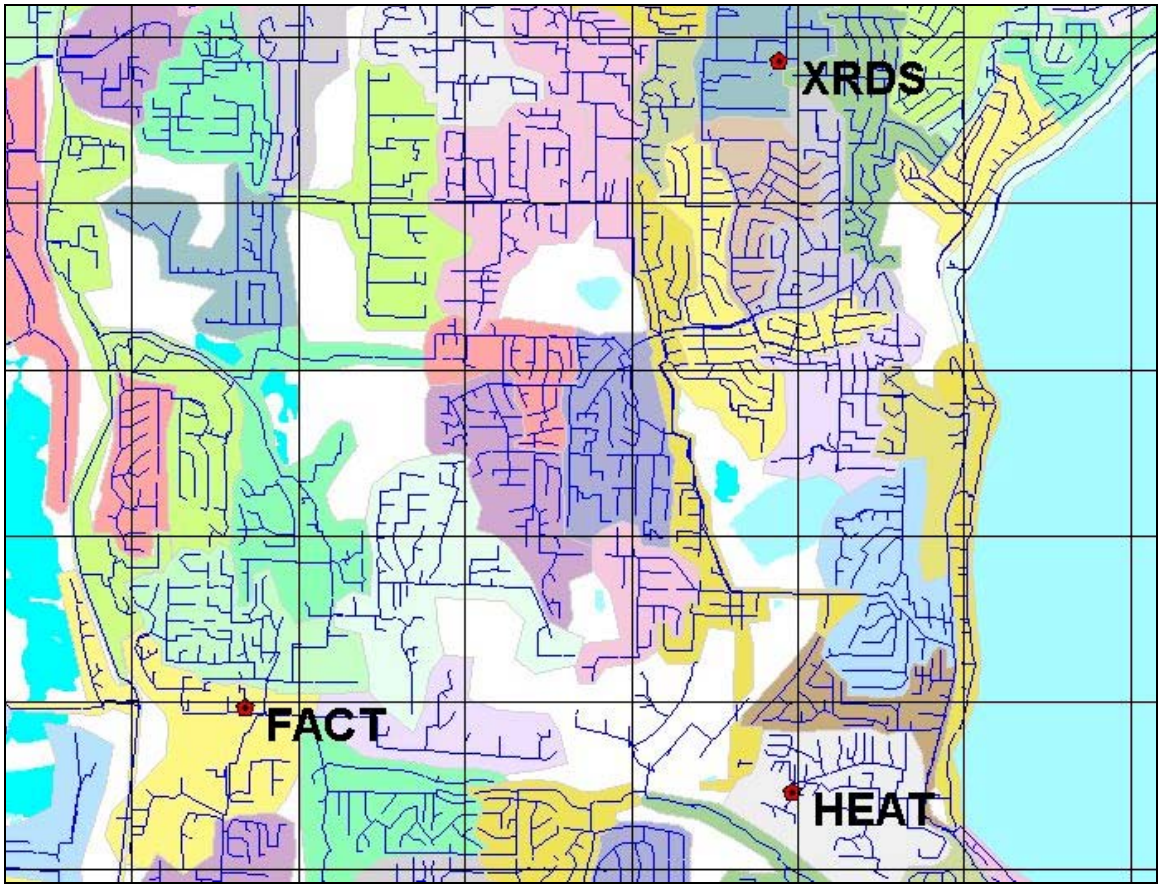
2003-2004 Post-Rehab Monitoring Season

Storm Number	Storm Start Time	Storm End Time	King County Calibration Zones								Storm Average	No. of Gauges in Calibration
			Lynnwood	Redmond	N. Seattle	Bellevue	S. Seattle	Seatac	M. Valley	Auburn		
1	10/19/2003 22:30	10/21/2003 5:00	89%	100%	100%	91%	79%	100%	100%	100%	95%	69
2	11/17/2003 18:00	11/19/2003 3:30	86%	71%	100%	82%	87%	75%	100%	78%	85%	70
3	11/28/2003 10:00	11/28/2003 22:00	82%	100%	100%	91%	81%	100%	100%	89%	93%	74
4	12/4/2003 15:30	12/4/2003 18:15	73%	100%	100%	90%	100%	100%	100%	100%	95%	
	12/4/2003 19:55	12/5/2003 0:00	100%	86%	100%	50%	87%	100%	100%	100%	90%	
	12/5/2003 3:00	12/5/2003 7:00	91%	100%	79%	91%	100%	100%	100%	100%	95%	
	12/5/2003 7:00	12/5/2003 12:00	64%	100%	64%	73%	93%	100%	100%	78%	84%	73
5	1/14/2004 2:10	1/14/2004 23:55	82%	86%	100%	82%	88%	100%	80%	75%	87%	71
6	1/23/2004 13:30	1/23/2004 22:20	100%	100%	100%	82%	87%	100%	100%	100%	96%	71
7	1/29/2004 3:00	1/29/2004 16:00	80%	100%	100%	78%	80%	88%	100%	100%	91%	
	1/30/2004 0:00	1/30/2004 2:30	100%	71%	100%	78%	80%	100%	100%	100%	91%	65
		Average % within 20%	86%	92%	95%	81%	87%	97%	98%	93%	91%	

Pixel Rain Data

In its most basic form, the output from CALAMAR is a series of rainfall measurements for every 1 km^2 pixel in the service area. To provide perspective of 1 km^2 pixels and 20,000 linear foot mini-basins, a collection of mini-basins in the City of Bellevue with 1 km^2 pixels superimposed is shown in Figure 3. Also shown are three of several rain gauges that will calibrate this zone. Sanitary sewer lines are shown in each colored mini-basin. CALAMAR produces a digital hyetograph for each pixel.

Figure 3
Bellevue Mini-basins, Three Rain Gauges and 1 km^2 Pixels

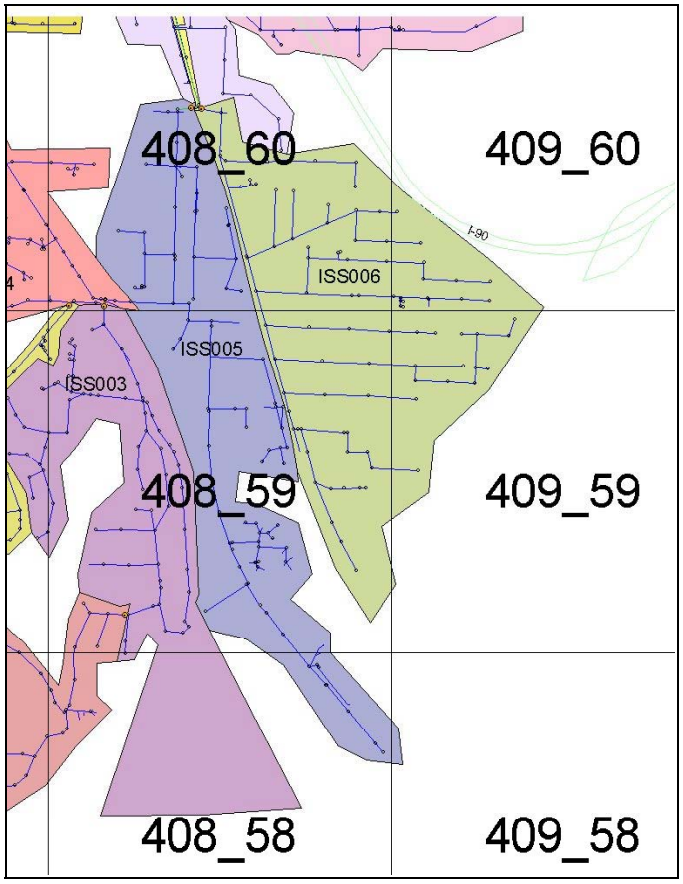


Conversion from Pixel Data to Mini-basin Rain Data

A CALAMAR rainfall data file was created for each of the pilot project mini-basins. Many of the mini-basins are positioned in multiple pixels, and Geographic Information System (GIS) was used to determine the percent of the area of each mini-basin in each pixel. Figure 4 shows several mini-basins located in Issaquah and the CALAMAR pixels overlaid on the mini-basins. The pixel numbers were derived from the approximate location in kilometers of the northwest corner of each pixel. The numbering system is

similar to the Washington State Plane Coordinate system. For example the pixel 408_59 is located 408 km east and 59 km north of the coordinate starting point.

Figure 4
Issaquah Mini-basins and CALAMAR Pixels



As shown in the above figure, Mini-Basin ISS005 falls into multiple pixels. Table 5 illustrates how GIS was used to determine the percent of the area of each mini-basin in each pixel. The yellow highlighting is on the 5 pixels that contribute rainfall to Mini-Basin ISS005, and the column "Percent" lists the percentage of each pixel. For example, nearly 54 percent of the rain on Mini-Basin ISS005 comes from pixel 408_59. This process produces both time series and accumulated rainfall data for each mini-basin.

Table 5
Determination of Percent of Rainfall on a Mini-basin

BASIN	PERCENT	EAST	NORTH	PIXEL
ISS004	0.0002	406	60	406_60
ISS004	0.0311	407	59	407_59
ISS004	0.1228	407	59	407_59
ISS004	0.0000	408	59	408_59
ISS004	0.0000	408	59	408_59
ISS004	0.7432	407	60	407_60
ISS004	0.0357	408	60	408_60
ISS004	0.0670	408	60	408_60
ISS005	0.0052	409	58	409_58
ISS005	0.1000	408	58	408_58
ISS005	0.5397	408	59	408_59
ISS005	0.3549	408	60	408_60
ISS005	0.0001	408	60	408_60
ISS006	0.2003	409	59	409_59
ISS006	0.0006	409	59	409_59
ISS006	0.1273	409	60	409_60
ISS006	0.3393	408	59	408_59
ISS006	0.3326	408	60	408_60
ISS007	0.1790	409	60	409_60
ISS007	0.3648	409	61	409_61
ISS007	0.0389	408	61	408_61
ISS007	0.2614	408	60	408_60
ISS007	0.1560	410	61	410_61

Once the CALAMAR rainfall time series were generated, these data were substituted into the rain gauge time series to become a composite rainfall time series.